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ABSTRACT

This paper explores the applicability of the concept of task/technology fit (TTF) to investigate the relationships between organizational tasks and the use of different mobile applications in an enterprise setting. Although the results are inconclusive as far as the viability of the TTF construct is concerned, they do point out clearly that (a) significant benefits can indeed be derived from the usage of mobile business applications, and (b) usability factors as perceived by the users, including system performance play a major role, in particular in the early phases of technology development. Besides providing directions for future research, the findings can support the decisions of system developers as well as of those in charge of implementation decisions.

Keywords

Mobile Commerce, Wireless Technologies, Theory of Task/Technology Fit, Empirical Study.

INTRODUCTION

Mobile technologies have gained attention in their ability to support business processes, in particular when integrated with Internet-based technologies (Economist 2001). Using such devices as cell phones, personal digital assistants (PDAs) and laptops with built-in wireless modems, employees can now connect to the company's information system at times when they are away from the office and would otherwise be unable to access the system. Removing the location-based access requirement promises to alleviate process bottlenecks, to improve productivity when idle time (e.g., waiting for a flight) is turned into productive time, to improve decision quality through greater access to information, and to improve the handling of emergency situations.

This paper sets out to investigate the relationships between the organizational tasks that a user performs and the use of mobile business applications, as well as the resulting benefits and impacts. Empirical data was collected at a Fortune 100 company in the telecommunications sector over a period of three months at the end of 2002.

RELATED RESEARCH

The use of mobile technology in enterprise settings has received growing attention (Varshney, Mallow, Jain and Ahluwalia 2002). Suggested benefits include improved productivity, lowered operational cost, increased customer satisfaction, and improved decision-making (Varshney et al., 2002). In an empirical study of mobile applications in an enterprise setting, Beulen and Streng (2002) utilize organizational adoption and diffusion models, such as the one proposed by Kwon and Zmud (1987) and the technology acceptance model (TAM) by Davis (1989), to derive empirical evidence for the impact of mobile commerce applications on the effectiveness and efficiency of mobile workers.

Research on technology innovation and diffusion has long pointed out the importance of matching IS with the organizational tasks to be supported or automated (Kimberly 1981), as a precursor to system use and subsequent benefits.

One such approach is the theory of task/technology fit (TTF). Goodhue and Thompson (1995) proposed the concept in their search for better methods to assess the success of information systems beyond self-reported user evaluations. Zigurs and Buckland (1998) matched the features of group support systems with the requirements of group tasks. The concept has its

roots in earlier attempts to provide guidelines for the development of decision support systems that are tailored to different decision-making situations (Benbasat, Dexter and Todd 1986). This idea was later extended to explain technology adoption in manufacturing settings (Cooper and Zmud 1990) as well as to interorganizational relationships (Bensaou and Venkatraman 1995). More recent work has extended Goodhue and Thompson's work and integrated it with the TAM (Dishaw and Strong 1999), while other authors have applied Zigurs and Buckland's (1998) framework to gain further insights on the success factors of group work (Murthy and Kerr 2000).

RESEARCH MODEL

This study applies the concept of TTF (Goodhue and Thompson 1995; Zigurs and Buckland 1998) to mobile business applications. Compared to the original models a broader range of tasks, technology functionalities and situational factors is included to explain the use of mobile applications in an enterprise setting (Figure 1). The study also incorporates the benefits that can be derived from usage and distinguishes between the potential of the application and actual usage and impacts. In detail, the following constructs are included in the research framework.

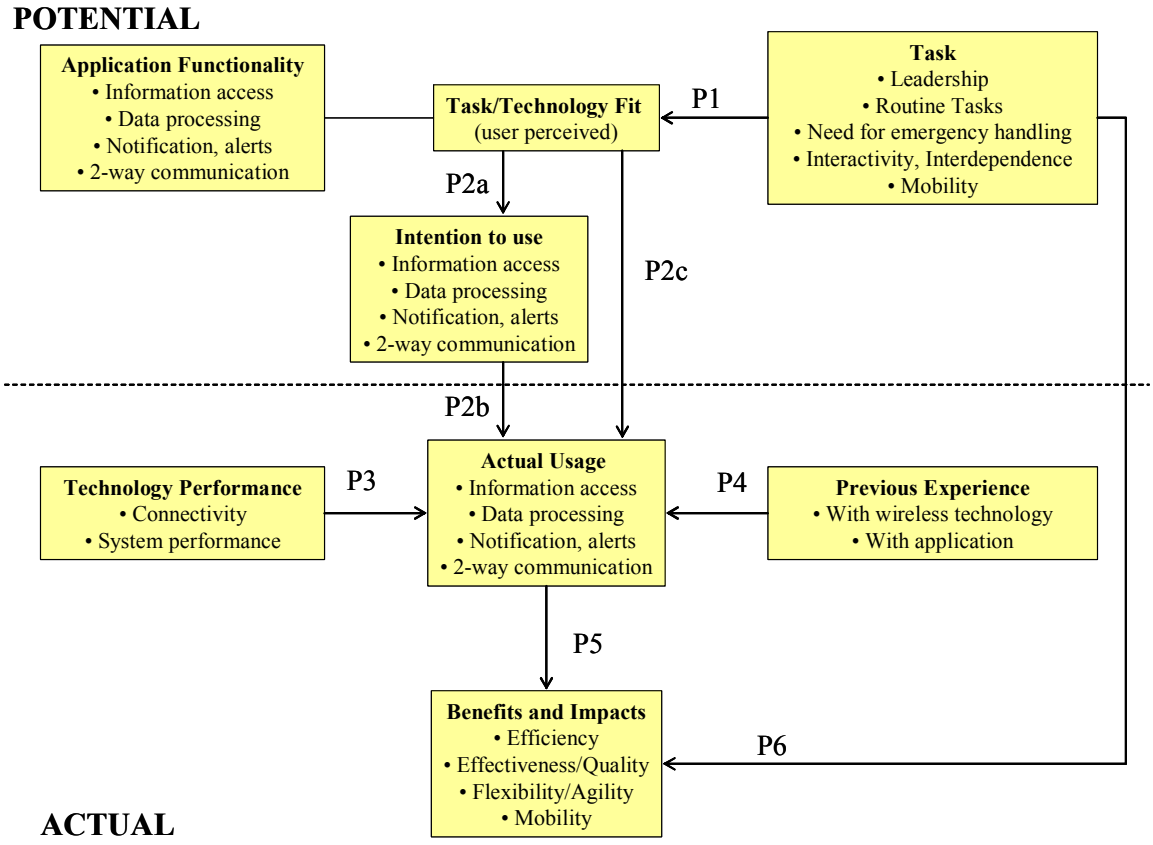

Figure 1. Research Model

Application Functionality

Accounting for the fact that wireless technology supports both data processing and communication, four functionalities are included in the framework:

- *Information access* incorporates activities where a user gains access to an information system in order to retrieve information and/or data.
- *Data processing* refers to application modules that allow for some degree of data manipulation by the user.

- *Notification* represents a form of "one-way" communication insofar as others can reach the user via notification and alerts but no immediate response can be sent through the system. This functionality also allows the user to initiate the communication process by accessing (e-mail) messages.
- *Two-way communication* includes mutual interaction between the user and the communication partner, in particular via e-mail (creation in addition to access only).

Task Characteristics

To derive a construct for task description, earlier research on the tasks of office workers, most notably managers and knowledge workers (Mintzberg 1973, Anthony 1965), is combined with the characteristics of a mobile workforce. Specific factors include:

- *Structure*, in particular the degree of leadership (vs. routine tasks) that a user might have;
- Need for *emergency handling and immediate decisions*;
- *Interactivity and interdependence* with others inside and outside the organization; and
- *Mobility*, to determine the location from where a task is performed.

Task/Technology Fit

The fit between the technology (= application functionality) and task characteristics was constructed as the degree of usefulness of an application as perceived by the user. Earlier studies used a more mechanical approach, such as counting the features for software application tools (Dishaw and Strong 1999). Such an approach is not feasible in our case given the broader focus to include different applications and tasks, and the fuzziness of a technology still in pilot stage. Goodhue and Thompson (1995) have applied user-perceived fit constructs as well. The closeness of this construct to the construct of perceived usefulness of the TAM allows for linkages between the different approaches in the future.

Usage

Actual usage was assessed with respect to the four functionalities outlined above, and on an overall basis. The intention to use was included as expressed by the users after the completion of a training course, as well as actual usage after system implementation.

In addition to a general fit between application functionality and tasks, two constructs were included that might have additional influence on the actual usage: technology performance and previous user experience.

Technology Performance

Gebauer, Shaw and Zhao (2003) found a strong relationship between system performance and the actual usage of a wireless system. Two factors are relevant:

- *Connectivity* refers to the quality of wireless service that a user experiences in his regular environment, as well as in the areas where the user would typically travel.
- *Performance* refers to the quality of the wireless system, as perceived by the user after starting to use the service.

Previous experience

The level of previous experience helps to determine how much effort a user has to go through to understand and to fully utilize an application. To assess the degree of change related to the application, two factors are relevant:

- Earlier experience with wireless technology
- Previous experience with the wireless application (functionality).

As the applications become more integrated into the operations of the firm, the impact on business processes (that is, related process changes) should also be taken into consideration.

Benefits and Impacts

Four items compose this construct; three are benefits and one is an impact related to the mobility resulting from the wireless applications.

- *Efficiency* relates to benefits from increased productivity of the user and of the people a user interacts with. It includes reductions in idle time while out of the office and the possibility to be more prepared upon returning to the office.
- *Quality* refers to the possibility to make better decisions while out of the office and without immediate access to the regular information system.
- *Flexibility* refers to the possibility to react faster to changing conditions and requirements inside and outside the organization.
- *Mobility* captures system-related changes of the places that the respondents work or travel, and the frequency with which they work from the different places.

PROPOSITIONS

A set of propositions helped validate the research model and lay the foundation for future research (depicted also in Figure 1):

P1 ***There is a fit between task characteristics and application functionality.*** Employees with different tasks value the functionality of different applications differently and vice versa.

P2a ***Task/Technology fit (perceived usefulness) is related with the intention to use the corresponding wireless applications.*** Employees indicating the usefulness of the wireless solution also intend to use it.

P2b ***Intention to use is related with actual usage of the corresponding wireless applications.*** Employees indicating an intention to use the wireless solution actually use it.

P2c ***Task/Technology fit (perceived usefulness) is related with actual usage of the corresponding wireless applications.*** Employees indicating the usefulness of the wireless solution actually use it.

P3 ***Technology performance is related with actual usage.*** Employees who are satisfied with the performance of the wireless system (continue to) use it.

P4 ***Previous experience is related with actual usage.*** Employees who already have some experience with the wireless system are likely to use the wireless solution.

P5 ***Actual usage of the wireless solution is related with benefits and also has impacts on employee mobility.*** Employees who use the system experience benefits regarding task performance and an impact on mobility.

P6 ***Task characteristics are related with benefits and an impact on mobility related with the wireless solution.*** Employees with different individual tasks structures report different consequences of using the wireless solution.

METHODOLOGY

To validate the research framework, three surveys were conducted at a Fortune 100 company in the telecommunications industry.

The surveys covered two mobile systems that had been developed and implemented independently from each other at the company. The first system was provided wireless access to the corporate directory, email, and the online procurement system. This system was just rolled out on a pilot basis in the U.S. and Japan. Two surveys were administered prior to the rollout (before and after a training session), while a third survey was administered shortly after the rollout. The second system concerned a wireless e-mail application that had been in use for several months in the U.K. To analyze the usage and implications of this system a post-implementation survey was administered that was very similar to the third survey administered in the U.S. and Japan. Data were collected between October and December 2002. The participants of the first two surveys were selected by the corporate sponsor based on their role in the organization and their level of participation with the existing procurement system. All respondents had some authority to approve purchasing requests.

All applications were accessible via mobile phones and were based on the WAP standard and iDEN technology. Login procedures required a combination of login name, password, pin, and/or a physical access card.

The survey items were adapted from earlier research (Agarwal and Prasad 1999; Lucas and Spitler 1999; Mintzberg 1973) and developed by the authors. While the majority of the survey items used a seven-point Likert-scale, some were of open numeric and text-based format. The latter were included to provide additional insights. A total of 38 surveys were received from 27 participants, among them were:

- 15 surveys on the pre-implementation phase administered *prior* to a training session (U.S. and Japan)
- 7 surveys on the pre-implementation phase administered *after* the training session (U.S. and Japan)
- 16 surveys on the post-implementation phase (U.S., Japan, and U.K.)

The small sample size precludes statistical testing beyond descriptive analyses, effectively rendering the study exploratory in nature. Besides the computation of bivariate correlations between the different variable constructs, a cluster analysis on task characteristics was performed and free-form comments were included into the analysis.

RESULTS

An analysis of the *task profiles* of the participants resulted in the identification of five key determinants:

- *Leadership*, including project initiation and leadership, monitoring of internal processes, resource allocation, and significant impact on the productivity of others;
- Degree to which *routine tasks* were performed;
- *Interdependence and interaction* pertaining to the level of interaction with colleagues and staff inside and outside the organization, as well as networking activities;
- *Need for emergency handling*, related to the need to deal with emergency situations and to make immediate decisions; and
- *Mobility*, concerning the time spent in and away from the office, including travel and work from home.

The respondents reported a high level of interaction with colleagues and an overall strong need for emergency handling (Table 1). Leadership tasks were more often performed than routine tasks, while overall mobility was moderate. Significant correlations were found among leadership tasks and the need for emergency handling (a positive correlation of 0.7, significant at the 0.01 level) and routine tasks and mobility (a negative correlation of 0.4, significant at the 0.05 level).

	Leadership tasks	Routine Tasks	Interdependence and interaction	Need for emergency handling	Mobility
N	27	27	27	27	27
Mean	5.01	3.33	5.98	5.04	3.41
Std. Dev.	1.18	1.39	.70	1.34	.912

Table 1. Tasks (Responses range from 1 = "task is never performed"/"situation never occurs" to 7 = "task is always performed"/"situation always occurs")

Based on these clusters three groups of participants were identified:

- *Leaders* who also experienced the most significant need to handle emergency situations;
- *Networkers* (middle management and knowledge workers); and
- *Performers of routine tasks* (also least mobile).

The moderate variation among the responses regarding the task characteristics points to a rather homogeneous group of respondents.

P1 – There is a fit between task characteristics and application functionality.

To assess P1, the relationship between the characteristics of the mobile applications and the task profiles of the respondents were analyzed. As outlined earlier, the fit measure was based on the user-reported usefulness of an application. Overall, respondents most valued the possibility to receive notifications and alerts as well as to access e-mails (Table 2), followed by e-mail creation and access to information, such as the corporate directory or procurement related data (e.g., requisition tracking). The possibility to use mobile technology to process data (e.g., to approve purchase requisitions) was considered the least useful among the applications.

	Information Access	Data Processing	One-way communication (notification, alerts, e-mail access)	Two-way communication (e-mail creation)
N	19	19	20	20
Mean	4.21	3.33	5.47	4.35
Std. Dev.	1.13	1.64	2.13	1.27

Table 2. Usefulness of mobile applications (fit) (Responses range from 1 = strongly disagree with a statement such as "the application is very useful to me" to 7 = strongly agree with the same statement)

P1 was confirmed only partially, as no more than a couple of significant links were found between task characteristics and perceived usefulness of different wireless applications, the measure for fit between task characteristics and mobile technology: Respondents whose tasks involved significant interaction and interdependence with others tended to have *little* appreciation for wireless access to information and data (in particular of access to the electronic procurement system), as well as data processing (also most significantly linked with e-procurement). Both correlations were significantly negative at 0.05 levels.

Relationships among the different applications were found: Respondents who valued information access also tended to value data processing (significant at the 0.05 level). High appreciation of wireless notification, alerts, and access to e-mail (one-way communication) were correlated with high appreciation of two-way communication (e-mail creation).

An overall measure of the fit across all different applications did not yield significant correlations with any of the tasks characteristics. While this finding strengthens the belief that the group of respondents was rather homogeneous, it also prevents the confirmation of P1.

P2a – Task/Technology fit (perceived usefulness) is related with an intention to use the corresponding wireless applications.

To test P2a, we asked about the intention to use the system (after training, but before implementation). The responses were quite positive, as on average, the respondents indicated an intention to use the wireless system for 36% of their procurement tasks (data processing) for 35% of their emails, and for 10% of their directory searches. More than half of the respondents (57%) indicated they would use the system whenever they were away from their desks for several hours, while 29% indicated they would use the system when they were out of the office for a full day. None of the respondents indicated that they had no intention to use the system.

The correlation between the general intention to use the system and its overall fit (usefulness) was strong (0.91) and significant at the 0.01 level. This result can be attributed particularly to respondents who indicated an intention to use the wireless system when away from their desks for several hours (that is, relatively frequently), in combination with a high appreciation (fit) for notification and alert functionalities.

Further correlations that were found to be significant at the 0.05 levels include a reported fit and intention to use the wireless solution for information access (correlation: 0.81) and for data processing (correlation: 0.76). As a result, P2a was confirmed.

P2b – Intention to use is related with actual usage of the corresponding wireless applications.

Moving from the potential of the wireless system to its actual impacts, the intention to use the system was related to the actual usage (after training and implementation, user-reported). Similar to usefulness, actual usage for one-way communication purposes (notification and alerts, e-mail access) was highest. The analysis of this part suffers from two weaknesses. First, the actual usage of the mobile applications other than e-mail, and in particular for procurement (data processing), was very low, mostly due to the fact that technical incompatibilities had prevented the respondents in Japan to access the mobile e-procurement system with their regular handsets, while respondents in the U.K. had no access to wireless e-procurement in the first place (only e-mail). Second, no data was collected on the original intention to use the wireless system from users in the U.K. because this survey was administered after the beginning of the implementation phase.

As a result, no significant correlations were found between intended and actual usages for any of the functionalities. It is interesting to note, however, that over 30% of the respondents who answered the particular question said that they did not use the wireless system at all (compare to the fact that none of the post-training/pre-implementation respondents indicated that they would never use the wireless system). We could not confirm P2b.

P2c – Task/Technology fit (perceived usefulness) is related with actual usage of the corresponding wireless applications.

P2c was supported on a general level, but not when applied to specific applications. In particular, significant correlations were found between general usage and the usefulness of the wireless system for (a) notification purposes (correlation of 0.6, significant at the 0.05 level), and (b) for 2-way communication (e-mail creation) (correlation of 0.5, significant at the 0.05 level). In addition, respondents who indicated that they *never* actually used the system also tended to indicate a *low* appreciation for notification and for e-mail creation (correlation significant at the 0.01 level).

P3 – Technology performance is related with actual usage.

Overall usage was correlated significantly (0.01 level) and strongly (0.67) with perceived technology performance, a variable including the quality of mobile service (connectivity) and overall system performance. This finding is complemented by that fact that respondents who indicated that they *never* used the wireless system also tended to perceive the performance of the system as low. No direct links between system performance and the actual usage of specific applications was found.

Additional insights regarding the impact of technology performance on actual usage can be obtained from an analysis of the free-form comments. Several lengthy comments described functional shortcomings as well as difficulties with system usage. In particular the following points were mentioned (in decreasing order): Tedious *login procedures*, including the need to enter several passwords and to carry a physical access card; *system performance*, including low speed of data transmission and access, and low bandwidth; and the lack of certain *functionality*, such as the possibility to process e-mail attachments, especially when complex, lack of support for Japanese characters, and access to other enterprise applications. Other factors mentioned were *limitations of the handsets*, in particular because of small screens; *reliability* problems; lack of *communication* from the project group; and finally *cost*. Together with the quantitative analysis of the survey responses, the comments strengthen our decision to accept P3.

P4 – Previous experience is related with actual usage.

Most participants reported previous experience with wireless devices, in particular mobile phones (100 %), personal digital assistants (PDAs) (67 %) and one or two-way pagers (53%). The respondents also expressed high familiarity with the functions of the wireless system. The mean response was 6.12 on a scale from 1 (not familiar at all) to 7 (very familiar).

Overall, only weak support was found for P4, as only one correlation was significant (at the 0.01 level): Respondents who were familiar with the functions of the wireless system, also tended to use the system to a larger extent for data processing than respondents with less experience. No connection was found between previous experience with various wireless devices and actual usage of the wireless system.

P5 – Actual usage of the wireless solution is related with benefits and also has impacts on employee mobility.

Survey data and free form comments showed that actual users of the wireless system experienced significant benefits. The ratings for quality, flexibility and efficiency benefits were very similar (Table 3). The effect on mobility (ability to spend less time in the office, travel less etc.) was reportedly lower. All bivariate correlations between the benefits and mobility impacts were significant at the 0.01 levels.

	Efficiency	Quality (Effectiveness)	Flexibility	Mobility
N	16	16	16	16
Mean	4.56	4.62	4.61	3.08
Std. Dev.	2.19	2.00	1.98	1.74

Table 3. Benefits and impacts of mobile applications (Responses range from 1 = strongly disagree with a statement such as "the application is very beneficial to me"/"has a strong impact on me" to 7 = strongly agree with the same statement)

P5 was supported to the extent that a significant relationship was found between overall usage and all of the benefits (efficiency, quality and flexibility) (0.05 or 0.01 levels). In addition, overall usage was related with impacts on mobility, indicating that the use of the wireless system allowed users to travel less frequently, to work from home more often, and/or to spend less time in the office (0.01-level). Regarding the usage of specific applications and related impacts, only one link was significant at the 0.05-level: The users of the wireless application to create e-mail (two-way communication) also tended to report impacts on mobility.

P6 – Task characteristics are related with benefits and an impact on mobility related with the wireless solution.

P6 was not confirmed, as no significant relationships were found between any of the task characteristics and benefits of the wireless applications or impacts on mobility.

Figure 2 summarizes the findings.

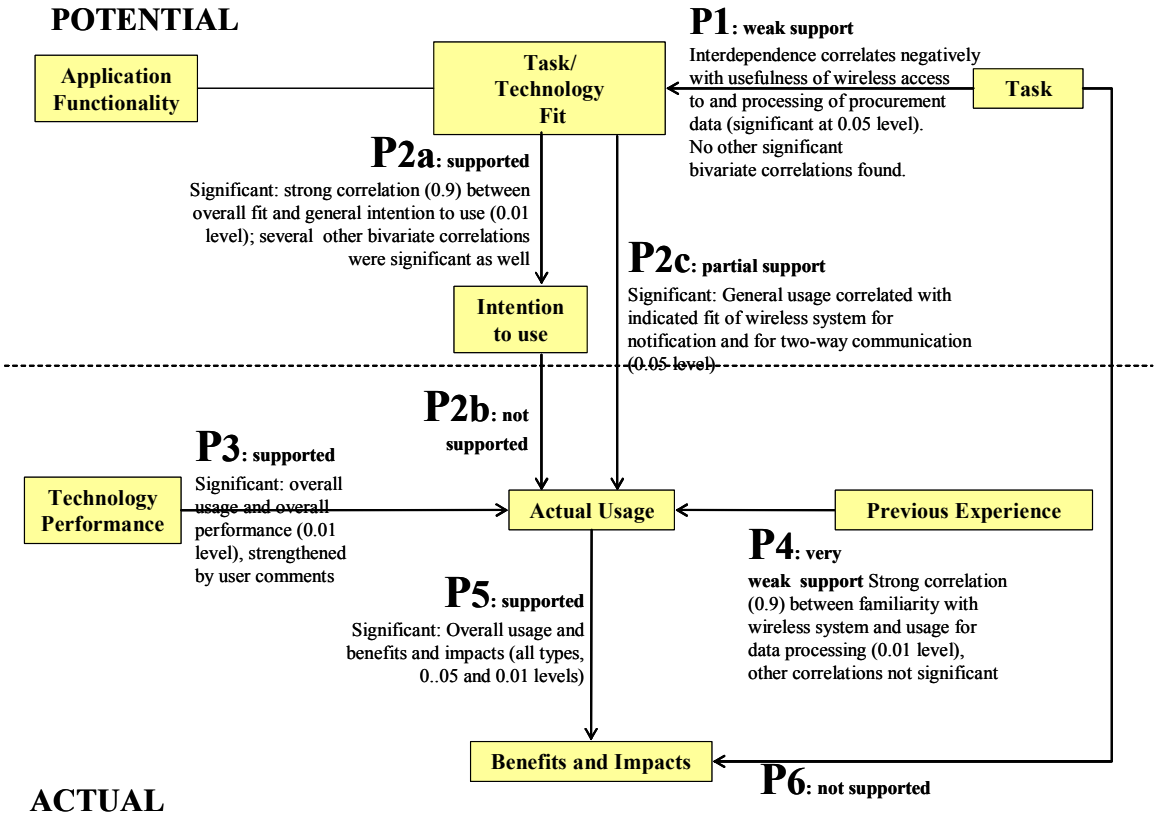

Figure 2. Results of data analysis

DISCUSSION

This study explored the factors that affect the usage of mobile business applications, e.g., for wireless information access (corporate directory and electronic procurement data), data processing (online procurement system), one-way communication (notification, alerts and e-mail access), and two-way communication (e-mail creation). We were particularly interested in identifying differences of actual usage of the various applications that could be attributed to differences in tasks that a user has to perform, such as leadership tasks, routine tasks, and tasks that rely heavily on interaction with co-workers, and other factors such as the need for emergency handling and mobility. This match was inspired by our wish to investigate the applicability of TTF-constructs to mobile technologies.

Compared to earlier applications of the TTF-construct, a more comprehensive set of (managerial) tasks and technologies was included into the current study. The results of the study are promising, although not fully satisfactory. Several propositions were not supported (Figure 2). In particular, this study could not identify strong links between task characteristics and the usefulness of particular applications (P1 was not confirmed). Part of this result can be contributed to the small sample size and homogeneity from a task perspective. Further studies are necessary to confirm this.

Several indicators point to problems with the system under study that might have overlaid some of the propositions that could not be confirmed. A strong link was found between perceived fit (= usefulness) of the system and the intention to use it (P2a). Actual usage, however, could not be inferred from the intention to use, pointing to a factor of interference. In fact, technology performance was strongly and significantly correlated with actual usage (P3). Free form comments revealed difficult login procedures and poor system performance as possible causes. The problems weighed heavily in some cases ("just not worth the hassle") and probably prevented usage of the system by some respondents.

Despite the technical difficulties, respondents who were actually using the system to a larger extent, reported significant benefits (P5). The responses pointed to improvements of flexibility (ability to capitalize on business opportunities while out of the office), efficiency (productiveness), and effectiveness (decision-making quality). In addition, effects on mobility were evident. In their free form comments, respondents indicated appreciation of being better able to balance their time at work and at home, and to keep on top of things while away from their computers.

CONCLUSIONS

The purpose of this study was to identify promising usage areas for mobile business applications based on their suitability for different tasks. Even though not all of the research objectives could be met, two results are particularly noteworthy:

First, mobile applications received general appreciation and can yield significant benefits in organizational settings, including improvements of efficiency, effectiveness and flexibility, plus impacts on employee mobility. The study showed that it makes most sense to support leadership tasks with mobile applications, given that the need for emergency handling is felt most strongly among that group of respondents. Leaders (as well as networkers) also tended to be more mobile than employees in charge of routine tasks.

Second, the study points to the importance of usability, in particular in the early phases of technology development. The question remains open of how to balance user requirements with the cost of early trial applications in order to identify promising applications early and clearly.

Several approaches for future research can be identified. First, the validity of the TTF-model remains to be confirmed (or rejected) in a more conclusive way than this study was able to. We suggest studying mobile systems that have passed the early trial phase and reached a higher level of maturity. Second, greater explanatory power might be derived from integrating the TTF-model with additional factors, such as the ones considered in the technology-acceptance model (TAM). Eventually, contextual factors, such as the impact on (and of) the environment within which tasks are performed (e.g., processes) should be considered. Third, the management of mobile system development demands close attention, in particular the delicate act of balancing trial costs and efforts with the need to create a realistic and acceptable usage environment.

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